A Housing Energy Management Program Report

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1982/1983 SEASON INTERIM PERFORMANCE REPORT ON THE FIELD OPERATION OF A RESIDENTIAL SPACE HEATING SYSTEM (PROJECT REPORT #6B)

PREPARED FOR THE MINISTRY OF
MUNICIPAL AFFAIRS AND HOUSING
RESEARCH AND DEVELOPMENT SECTION

BY

THE CONSUMERS' GAS COMPANY LTD.

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1.0 INTRODUCTION

Recently, a number of ultra high-efficiency, residential sized, natural gas fueled condensing furnaces have been introduced into the marketplace by a variety of manufacturers.

The Consumers' Gas Company Ltd. and the Ontario Ministry of Municipal Affairs and Housing (MAH) share a mutual interest in these new energy efficient furnaces and decided jointly to field evaluate a model of a new market entry condensing furnace on a fifty-fifty funding basis.

This interim report covers the analysis of the data, collected over the 1982/1983 heating season. An earlier report entitled "Interim Report on the Field Operation of a Residential Space Heating System" ISBM No. 0-7743-8801-3, was published in June 1983, which covered the installation of the furnaces.

2.0 OBJECTIVE OF EVALUATION

The objective of this project is to ascertain the performance, operating costs, reliability and acceptability of this new design condensing gas furnace and compare these costs to those of an electric furnace and a conventional standing pilot gas furnace, over the 1982/1983 and 1983/1984 heating seasons, respectively.

3.0 FURNACE SYSTEM UNDER EVALUATION

The condensing gas furnace being evaluated is installed in Whitby, Ontario. The high-efficiency condensing gas furnace is compared to a hard reference electric furnace. The electric and condensing gas units were initially alternated on a weekly basis for 3 weeks beginning November 11, 1982. After that, furnace operation was alternated on a daily basis, with the electric furnace being utilized one day for a 24-h period and the gas furnace being operated on the other day, again for a 24-h period.

The condensing gas furnace under test is directly vented via an Acrylonitrile-Butadiene-Styrene (ABS) pipe, thus requiring no chimney or flue, as the exhaust gas products are vented directly to the outside through the nearest wall.

4.0 SITE READINGS AND RESULTS

The site at Whitby is a fully detached two-storey frame house with a walk-out basement. The total heated area is 330 m^2. The existing conventional gas furnace is left in place and will be utilized in the field evaluation during the latter part of the 1983/1984 heating season. The high-efficiency condensing gas furnace of 29.3-kW rated capacity, and the hard reference electric furnace of 20.6-kW rated capacity are installed in parallel to each other and to the existing conventional gas furnace. The interconnecting duct work is provided with isolating dampers, which are inserted or removed dependent on which furnace is being utilized.

Readings are taken on a daily basis from each appliance, and the actual energy consumed over the 1982/1983 season for each furnace is shown in Table 1.

The condensing gas furnace operated for a total of 91 days during the 1982/1983 heating season and consumed 1 027.7 m^3 of natural gas and 45.8 kW·h of electricity for the circulating air fan for a total consumption over the period of operation of 38 425 MJ. During this period, 2 265 celsius degree days were recorded on site. The consumption per celsius degree day for this appliance is 16.96 MJ.

TABLE 1

CONDENSING GAS FURNACE AND ELECTRICAL FURNACE EVALUATION
SUMMARY OF 1982/1983 ACTUAL HEATING CONSUMPTIONS

	CONDENSING GAS FURNACE					ELECTRIC FURNACE		
Month	Mean Daily Temperature (°C)	Electricity Consumption (kW·h)	Gas Consumption (m^3)	No. of Days Operating	Degree Days (C° Days)	Electricity Consumption (kW·h)	No. of Days Operating	Degree Days (C° Days)
November	4.0	7.8	161.2	15	366.3	540.7	6	98.0
December	1.1	6.8	182.1	15	485.8	2 068.6	12	368.8
January	-0.2	1.7	91.5	6	133.2	1 198.8	7	247.5
February	1.2	12.0	213.9	14	545.8	2 002.8	14	513.7
March	2.5	8.8	197.2	15	334.7	1 096.1	16	361.5
April	6.8	6.2	127.9	15	264.2	1 086.3	14	271.5
May	14.5	2.5	53.9	11	135.0	383.1	8	163.9
Total		45.8	1 027.7	91	2 265	9 376.4	77	2 024.9
Megajoules (MJ)		(165)	(38 260)			(33 755)		
Total Megajoules (MJ)		(38 425)				(33 755)		
Consumption Per Degree Day (MJ/C° Day)		16.96				16.67		

NOTE: Assuming the electric furnace to be 100% efficient at site, comparison of the consumption per degree day of each furnace will give an indication of the seasonal efficiency of the condensing gas furnace. This comparison calculates to 98.29%.

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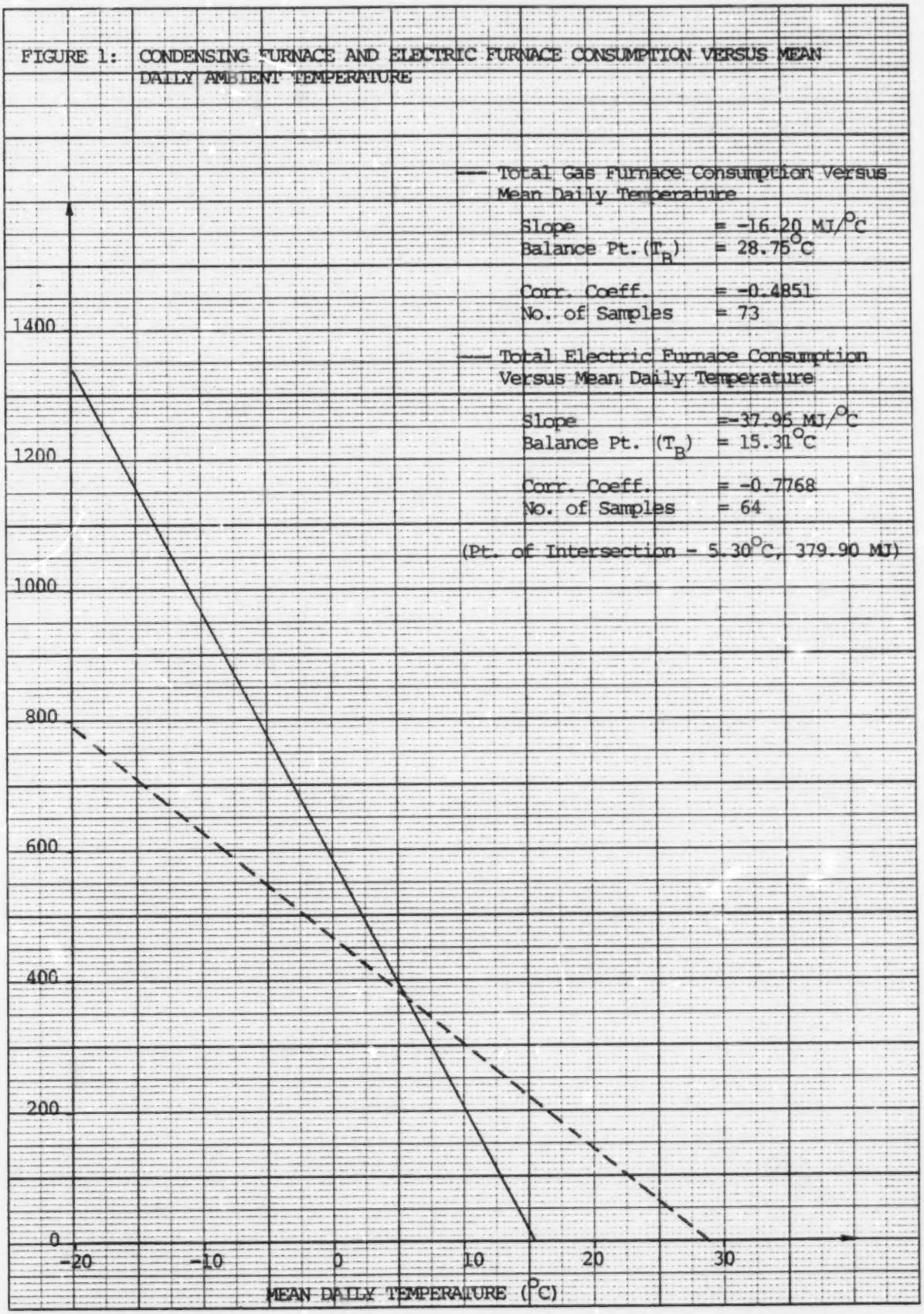
The electric furnace, which can be assumed to be 100% efficient at site, consumed 9 376.4 kW of electrical energy over a period of 77 days during the 1982/1983 heating season. During this period, the site recorded celsius degree days were 2 024.9, to give an energy consumption per celsius degree day of 16.67 MJ. Comparing these figures gives a seasonal efficiency for the condensing gas furnace of 98.29% which appears high. These figures are also shown in Table 1.

The daily energy consumption recorded at site for each furnace is plotted against daily mean outside temperature to produce a linear regression graph for each appliance. This regression is shown in Figure 1. The dotted line relates to the total energy consumption of the gas furnace and the solid line relates to the total energy consumption of the electric furnace. The absolute value of the correlation coefficient of the regression line for the electric furnace is significantly higher than that of the gas furnace (0.7768 versus 0.4851 respectively). Consequently, the level of confidence in the electric furnace data is significantly greater than in the condensing gas furnace data.

A degree of error is evidenced by the excessively large discrepancy in balance points indicated by the regression equations in Figure 1. A common balance point would be expected, since the furnace in operation does not affect the heating load of the house. The regression line for the condensing gas furnace indicates a balance point for the house of 28.75°C, which is unrealistically high.

FIGURE 1: CONDENSING FURNACE AND ELECTRIC FURNACE CONSUMPTION VERSUS MEAN DAILY AMBIENT TEMPERATURE



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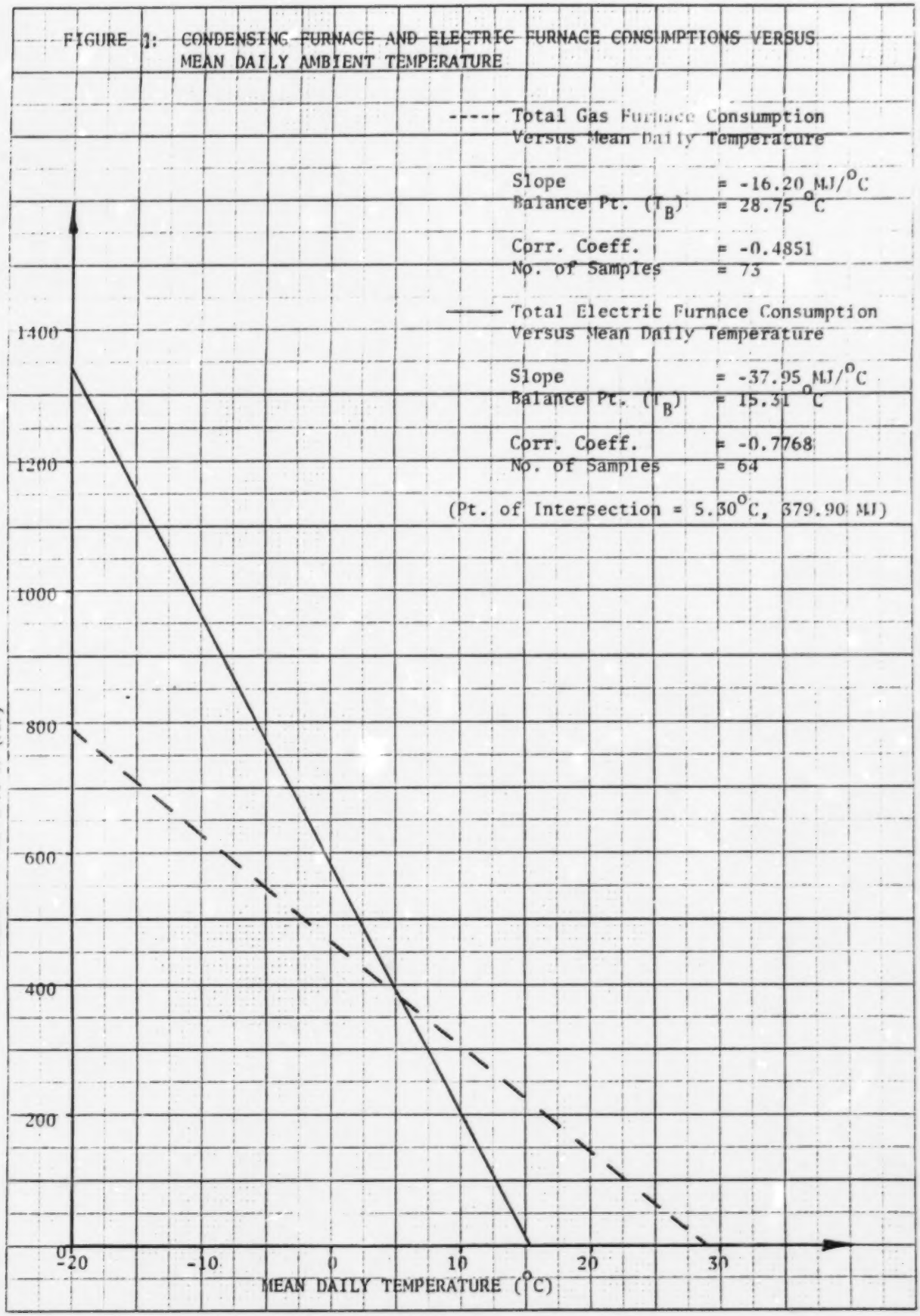
K+E 20 X 20 TO THE INCH • 7 X 10 CM
KEUFFEL & ESSER CO MADE IN U.S.A.

FIGURE 1: CONDENSING FURNACE AND ELECTRIC FURNACE CONSUMPTIONS VERSUS MEAN DAILY AMBIENT TEMPERATURE



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The balance point of 15.31°C from the regression line for the electric furnace is much more reasonable. Furthermore, the slope of the regression line of the electric furnace is much steeper than that of the gas furnace, which indicates that the gas furnace is more efficient at site than the electric furnace. This seems unreasonable, since the on-site efficiency of the electric furnace is construed to be 100%.

Furthermore, the set-back system programmed into the digital thermostat is difficult to handle in the manual analyses with a flip-flop alternate day changeover arrangement, because of the thermal lag and different pick-up times for either furnace. Set back thermostats are also subject to owner adjustment which is outwith the project control, but which introduces an unknown variable.

The diversity in the balance points appears to be a problem with either the instrumentation, the uncontrolled set back, or the recording of data. For the 1983/1984 heating season the instrumentation will be checked and the recording of data will be monitored closely, so that possible sources of error can be highlighted and eliminated early in the season.

Because the regressed lines are so unreasonable, any further analysis on the regression would not yield much more significant and valid information. Therefore the 1983/1984 season data will be used for a complete analysis with respect to consumption and cost.

5.0 COMMENT ON THE FUNCTIONAL OPERATION

Some problems with various components were encountered during field testing of the unit, and there was some concern that there may be a design fault in the unit. After the first few days of operation, the condensing gas furnace began to vibrate during operation. The vibration was not associated with the changes in ductwork, since no such problem had occurred during the operation of the electric and conventional gas furnaces. It was found, on inspection of the unit, that the purge blower was noisy, and was consequently replaced with a blower having a resilient mounting. The purge blower control relay was also found to be buzzing loudly -- this was rectified by simply tightening the mounting screws. The orifice in the exhaust was whistling, but after being cleaned and replaced, operated quietly. It was apparent that the blower motor is not acoustically isolated from the exhaust piping on this manufactured unit. These deficiencies were readily taken care of under warranty.

Following several more weeks of operation, the test furnace began to repeatedly cut out soon after starting. After the pilot timer, pilot mercury flame sensor plug, ignition wire, and internal fuse were replaced, the furnace operated properly. It was also found from the service contractor, who completed these repairs, that the thermo-switch malfunction was common in other furnaces of the same type. Some minor difficulties were also encountered with the electronic digital thermostat. Some difficulties were, in part, to be expected in testing a new unit, but this test furnace was hampered with more problems than other new furnaces field tested as part of other projects undertaken by The Consumers' Gas Company Ltd. in conjunction with MAH.

A condensate neutralizer kit can be obtained from the manufacturer to prevent acid condensate being introduced into the sewer system -- this component is not fitted to the furnace under test.

Tests performed by The Consumers' Gas Company Ltd. Laboratory Services on the condensing gas furnace indicated that condensate sample from the unit was slightly acidic (pH 4.1). Further samples will be taken next season.

Maintaining a clean filter is particularly important in order that optimum efficiency may be obtained. The air flow past the heat exchangers can become restricted since the air filter system is located upstream from the condensing heat exchanger. Consequently, the warm air plenum temperature could approach the limit control setting. These considerations suggest that this condensing gas furnace may require more stringent maintenance than a conventional gas furnace, but not to an extent to inconvenience the homeowner significantly.

6.0 CONCLUSIONS

(a) The unit was plagued with several problems, which were taken care of under warranty.

(b) The data produced appear to be unreliable so that a consumption and cost analysis at this time would not produce significant and valid information.

7.0 RECOMMENDATIONS

(a) The field evaluation will be continued for another heating season, with close attention being paid to data collection and reliability of homeowner recorded information.

(b) During the 1983/1984 heating season the thermostat will be set at a predetermined temperature of 20°C and maintained at that setting for the duration of the test.